The Possible Unemployment Cost of Average Inflation below a Credible Target *

Lars E.O. Svensson
Sveriges Riksbank, Stockholm University, CEPR, and NBER

www.larseosvensson.net

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Abstract
The Riksbank in 1993 announced an official target for CPI inflation of 2 percent. Over the last 15 years, average CPI inflation has equaled 1.4 percent and has thus fallen short of the target by 0.6 percentage points. Has this undershooting of the inflation target had any costs in terms of higher average unemployment? This depends on whether the long-run Phillips curve in Sweden is vertical or not. During the last 15 years, inflation expectations in Sweden have become anchored to the inflation target in the sense that average inflation expectations have been close to the target. The inflation target has thus become credible. If inflation expectations are anchored to the target also when average inflation deviates from the target, the long-run Phillips curve is no longer vertical but downward-sloping. Then average inflation below the credible target means that average unemployment is higher than the rational-expectations steady-state (RESS) unemployment rate. The data indicate that the average unemployment rate has been 0.8 percentage points higher than the RESS rate over the last 15 years. This is a large unemployment cost of undershooting the inflation target. Some simple robustness tests indicate that the estimate of the unemployment cost is rather robust, but the estimate is preliminary and further scrutiny is needed to assess its robustness.

JEL Classification: E24, E31, E52, E58

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The Riksbank in 1993 announced an official target for CPI inflation of 2 percent at an annual rate. Over the last 15 years, average CPI inflation has equaled 1.4 percent and has thus fallen short of the target by 0.6 percentage points (pp). Has this undershooting of the inflation target had any costs in terms of higher average unemployment? This depends on whether the long-run Phillips curve in Sweden is vertical or not. During the last 15 years, inflation expectations in Sweden have become anchored to the inflation target, in the sense that average inflation expectations have been close to the target. The inflation target has thus become credible. If inflation expectations are anchored to the target also when average inflation deviates from the target, the long-run Phillips curve is no longer vertical but downward-sloping. Then average inflation below the credible target means that average unemployment is higher than the rational-expectations steady-state unemployment rate (RESS) rate. The data indicate that the average unemployment rate has been 0.8 pp higher than the RESS rate over the last 15 years. This is a large unemployment cost of undershooting the inflation target. Some simple robustness tests indicate that the estimate of the unemployment cost is rather robust, but the estimate is preliminary and further scrutiny is needed to assess its robustness.

**Average inflation has fallen short of the target but inflation expectations have been anchored on the target**

The relevant data is shown in figure 1. It shows quarterly data from 1996 of real-time annual CPI inflation, inflation expectations from the survey the Riksbank has commissioned from TNS Sifo Prospera of annual CPI inflation one and two years ahead, and the unemployment rate (15-74 age group). Throughout this paper I assume that the TNS Sifo Prospera survey is representative of private-sector inflation expectations in Sweden.¹

Over the last 15 years, the period 1997-2011, average real-time CPI inflation has equaled 1.43 percent, thus undershooting the target of 2 percent by about 0.6 pp. Average revised CPI inflation was 1.31 percent during the same period. For the purposes of this paper, real-time inflation is more appropriate.²

During the same period, inflation expectations in Sweden became anchored to the inflation target in the sense that average inflation expectations were close to the target. Figure 2 shows five-year moving averages of inflation expectations one and two years ahead and real-time CPI inflation.

For the period 1997-2011, average inflation expectations one and two years ahead are 1.94 and 2.13 percent, respectively. My starting point is therefore that during the last 15 years inflation expectations have on average equaled the target of 2 percent and that average CPI inflation has fallen 0.6 pp below target.

¹ In 1995 the Riksbank commissioned Prospera Research (now TNS Sifo Prospera) to conduct a survey of the expectations of inflation and wage increases of a panel of labor market organizations, purchase managers, and money-market players. The first report was published in November, 1995. Initially the survey was to be published three times a year, but from 1996 the survey was conducted four times a year. Later the survey was expanded to include expectations of future GDP growth and repo rates and for money-market players also expectations of future 5-year government bond rates and USD and EUR exchange rates.

² As is explained in Sveriges Riksbank (2004), before 2005, CPI inflation was calculated by Statistics Sweden not as the annual percentage increase in the CPI but with a method that excluded substitution effects on the composition of the basket, making measured inflation on average 0.2 pp higher. From 2005, CPI inflation is calculated as the annual percentage change in the CPI.
Figure 1. CPI inflation, CPI inflation expectations one and two years ahead (all interviewees), and unemployment (15-74 age group)
Percent

Sources: Statistics Sweden and TNS Sifo Prospera.

Figure 2. CPI inflation expectations one and two years ahead (all interviewees) and CPI inflation, five-year moving averages
Percent

Sources: Statistics Sweden and TNS Sifo Prospera.
Average inflation expectations are economically and statistically significantly above average inflation.\(^3\) The inflation expectations are not rational, as shown in detail by Jönnson and Österholm (2012). Perhaps they are “near-rational” as in in Akerlof, Dickens, and Perry (2000) (ADP).

In ADP near-rational behavior means that, when inflation does not deviate too much from zero, a significant fraction of the private sector neglects inflation and behave as if it would equal zero. When inflation becomes sufficiently above zero, an increasing fraction of the private sector become rational and has rational expectations. The result is a long-run Phillips curve that is vertical for high inflation rates, for which the long-run unemployment rate equals the rational-expected steady-state (RESS) rate (what is often somewhat imprecisely called the “natural rate”, see Rogerson 1997). For low positive inflation rates, the long-run Phillips curve has a hump to the left and the long-run unemployment rate is lower than the RESS rate. For zero inflation, the long-run unemployment rate is again equal to the RESS rate (ADP p. 18, figure 1).\(^4\)

In the present context, near-rational behavior would mean that, when average inflation does not deviate too much from the inflation target of 2 percent, a significant fraction of the private sector neglects that deviation and behave as if average inflation would equal the inflation target. A possible explanation is that this fraction of the private sector may have been more influenced by the Riksbank’s communication of the inflation target of 2 percent than by actual average inflation. Thus, whereas near-rational behavior in ADP is with reference to zero inflation, here it would be with reference to the inflation target of 2 percent.

**The long-run Phillips curve has become downward-sloping**

If inflation expectations are anchored on the target in the sense that average inflation expectations equal the target even though average inflation deviates from the target, the long-run expectations-augmented Phillips curve is no longer vertical but downward-sloping.\(^5\) Consider the simplest expectations-augmented Phillips curve,

\[
\pi_t = \pi_e^t - \gamma(u_t - u^*) + \epsilon_t,
\]

where \(\pi_t\) denotes inflation in quarter \(t\); \(\pi_e^t\) denotes inflation expectations; \(u_t\) denotes the unemployment rate; \(u^*\) denotes the RESS rate; \(\epsilon_t\) denotes possibly serially-correlated cost push shocks with an unconditional mean equal to zero, \(E[\epsilon_t] = 0\); and \(\gamma\) is a positive constant. Taking the unconditional mean of the Phillips curve (1) then results in the long-run relation between inflation, inflation expectations, and unemployment,

\[
\pi = \pi_e - \gamma(u - u^*),
\]

where \(\pi = E[\pi_t]\), \(\pi_e = E[\pi_e^t]\) and \(u = E[u_t]\) denote the unconditional means of inflation, inflation expectations and the unemployment rate. Under rational expectations, the unconditional mean of inflation and inflation expectations are equal,

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\(^3\) A regression 1997-2011 of one-year-ahead inflation expectations less CPI inflation on a constant results in the constant 0.51 and a Newey-West error (lag 4) of 0.16.

\(^4\) Lundberg and Sacklén have estimated the ADP long-run Phillips curve on Swedish data. Bryan and Palmqvist (2010) test some particular hypotheses that follow from the ADP assumptions.

\(^5\) The anchoring of U.S. inflation expectations to 2 percent and the resulting downward-sloping U.S. Phillips curve have been noted by Fuhrer (2011).
\[ \pi = \pi^* \]

so the unconditional mean of the unemployment rate and the RESS rate are equal,

\[ u = u^* . \] \hspace{1cm} (3)

Then the long-run Phillips curve is vertical, the unconditional mean of the unemployment rate is independent of the unconditional mean of inflation, and there is no long-run tradeoff between inflation and unemployment.

However, if the unconditional mean of inflation expectations equals the inflation target, \( \pi^* \), regardless of the unconditional mean of inflation, the long-run Phillips curve will be

\[ \pi - \pi^* = -\gamma (u - u^*) . \] \hspace{1cm} (4)

The long-run Phillips curve is then downward-sloping with slope \(-\gamma\), and there is a long-run tradeoff between inflation and unemployment. When average inflation expectations equal the inflation target, average inflation below target will imply average unemployment above the RESS rate.

In order to estimate a long-run inflation Phillips curve, I first estimate a short-run Phillips curve with unemployment and two lags of inflation as explanatory variables,

\[ \pi_t - 2 = \beta_0 + \beta_1 (\pi_{t-1} - 2) + \beta_2 (\pi_{t-2} - 2) + \beta_3 u_t + \epsilon_t . \] \hspace{1cm} (5)

The result of estimating (5) for the sample 1998Q1-2011Q4 is shown in table 1. The coefficients on the two lags of inflation and on unemployment are highly significant.

I choose to estimate the short-run Phillips curve for the sample 1998Q1-2011Q4 rather than 1997Q1-2011Q4 in order not to exaggerate the unemployment cost of average inflation below the inflation target. As seen in figure 1, unemployment is very high in the beginning of the sample. As explained in the section on robustness tests, starting the sample earlier than 1998 leads to a flatter long-run Phillips curve with a larger unemployment cost whereas starting in 1998 or later leads to a similar slope of the long-run Phillips curve and a similar unemployment cost. The estimation is obviously under the maintained hypothesis that the sample mean of the “cost-push” shocks \( \epsilon_t \) are close to zero.

Table 1. Short-run Phillips curve, 1998Q1-2011Q4

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Estimate</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \beta_0 )</td>
<td>1.835275</td>
<td>0.528245</td>
<td>3.474290</td>
<td>0.0010</td>
</tr>
<tr>
<td>( \beta_1 )</td>
<td>1.127351</td>
<td>0.121112</td>
<td>9.308356</td>
<td>0.0000</td>
</tr>
<tr>
<td>( \beta_2 )</td>
<td>-0.500917</td>
<td>0.110455</td>
<td>-4.535029</td>
<td>0.0000</td>
</tr>
<tr>
<td>( \beta_3 )</td>
<td>-0.283695</td>
<td>0.080984</td>
<td>-3.503117</td>
<td>0.0010</td>
</tr>
</tbody>
</table>

Note: Newey-West standard errors (lag 4), \( R^2 = 0.84 \), adjusted \( R^2 = 0.83 \), S.E. = 0.51, DW = 2.12.

Taking the unconditional mean of the short-run Phillips curve (5) then results in the long-run Phillips curve

\[ \pi - 2 = \gamma_0 - \gamma u , \] \hspace{1cm} (7)

where \( \gamma_0 = \beta_0 / (1 - \beta_1 - \beta_2) \) and \( \gamma = -\beta_1 / (1 - \beta_1 - \beta_2) \). From the estimates in table 1 it follows that the long-run Phillips curve is

\[ \pi - 2 = 4.92 - 0.76 u . \] \hspace{1cm} (8)
Figure 3 shows the long-run Phillips curve (8) (black solid and dashed line) with a scatter plot with CPI inflation and unemployment for the sample 1998Q1-2011Q4 (red circles with connecting lines). The long-run Phillips curve is solid for average inflation rates less than 1 pp from 2 percent and dashed for average inflation rates farther from 2 percent, in order to emphasize that it is derived under the assumption that average inflation expectations are equal to 2 percent. It may apply only if average inflation does not deviate too far from 2 percent. If average inflation would deviate far from 2 percent, in line with the reasoning of ADP, a higher fraction of the private-sector would have rational expectations and the long-run Phillips curve would bend towards the RESS rate.

Figure 3. The long-run Phillips curve and scatter plot, 1998Q1-2011Q4

![Figure 3: The long-run Phillips curve and scatter plot, 1998Q1-2011Q4](image)

The unemployment cost of average inflation below a credible target

The slope of the long-run Phillips curve (8) in figure 3 is \(-0.76 = -1/1.32\), meaning that 1 pp lower average inflation is associated with 1.3 pp higher average unemployment.

The right black square on the Phillips curve in figure 3 shows the average unemployment rate, 7.26 percent, that is associated with average inflation equal to the historical average during 1997Q1-2011Q4, 0.6 pp below the target. The leftmost black square shows the average unemployment rate, 6.47 percent, that is associated with average inflation equal to target.\(^6\) The horizontal distance between the squares indicates the unemployment cost of average inflation having fallen short of the target by 0.6 pp. It is 0.79 pp. Thus, this analysis leads to an unemployment cost of about 0.8 pp excess unemployment on average

\(^6\) Under the assumption of a constant long-run RESS unemployment rate \(u^*\), from (7) and (8) it follows that \(u^* = \frac{\gamma_u}{\gamma} = 4.92/0.76 = 6.47\), so this number can be seen as an estimate of a constant RESS rate during 1997Q1-2011Q4. However, in the last few years, substantial structural reforms, tax changes, and other factors, including demography and labor force composition, have according to Forslund (2008), Ministry of Finance (2011), and National Institute of Economic Research (2011) probably reduced the RESS rate substantially.
for 15 years due to average inflation having undershot the target by 0.6 pp during this period. This is a large unemployment cost of undershooting the inflation target.

This estimate of the long-run Phillips curve and the associated large unemployment cost over the last 15 years seem relatively robust. A 99 percent confidence interval is 0.79±0.39 pp, that is, between 0.40 and 1.18 pp. As discussed in more detail in the next section, a Wald test rejects the hypothesis of a vertical long-run Phillips curve. Starting the sample earlier makes the Phillips curve flatter and the unemployment cost larger for given average undershooting of the target. Starting the sample later or ending the sample a few quarters earlier does not make the Phillips curve much steeper and the unemployment cost much smaller. Estimating the Phillips curve with CPIXF inflation instead of CPI inflation leads to the same unemployment cost.\(^7\) Estimating the Phillips curve with the Riksbank’s estimate of the unemployment gap instead of the unemployment rate leads to a higher unemployment cost in terms of the unemployment gap.

Some robustness tests

Can the hypothesis that the long-run Phillips curve is vertical and the unemployment cost is zero be rejected? If the coefficients \(\beta_1\) and \(\beta_2\) on lagged inflation sum to unity, the slope \(-\gamma\) is infinite, and the long-run Phillips curve is vertical. However, a Wald test strongly rejects that hypothesis. Given the estimates in table 1, this is not surprising, since we directly see that the sum of the coefficients is only 0.63 and the coefficients are relatively precisely estimated.\(^8\)

The rejection of a vertical Phillips curve is in contrast to the case in Rudebusch and Svensson (1999). There, a Phillips curve for the U.S. economy is estimated for the sample 1961Q1-1996Q2. The hypothesis that the coefficients on lagged inflation sum to unity cannot be rejected. Instead, the estimation is done under the restriction that the coefficients sum to unity and the long-run Phillips curve is vertical.

Figure 4 shows a scatter plot with unemployment and CPI inflation from 1976Q1 through 2011Q4. We see that the observations during the 1970s and the 1980s with large fluctuations in inflation give the impression that the long-run Phillips curve was vertical. The observations to the fare right are from the big crisis in the early 1990s. The sample 1998Q1-2011Q4 is marked in red. The observations indicate a non-vertical Phillips curve.

Starting the sample earlier than 1998Q1 leads to a flatter long-run Phillips curve and a larger unemployment cost. Figure 5 shows this for the sample 1997Q1-2011Q4. The slope is \(-0.40\) and the unemployment cost is 1.51 pp. The reason is that earlier observations have high unemployment rates, as can be seen in figure 1. This means more observations further to the right in figure 5 than in figure 3, which make the long-run Phillips curve flatter.

\(^7\) CPIXF inflation refers to CPIX inflation through 2008Q1 and CPIF inflation from 2008Q2. As explained in Sveriges Riksbank (2008), the price index CPIX differs from the CPI in that the effects of changes in mortgage costs and the direct effects of changes in indirect taxes and subsidies are excluded. The price index CPIF differs from the CPI in that mortgage costs are calculated with a constant mortgage rate. Through the Monetary Policy Update of April 2008, the Riksbank used CPIX inflation as an operational target. From the Monetary Policy Report of July 2008, the Riksbank has emphasized CPIF inflation rather than CPIX inflation.

\(^8\) The standard error of the sum of the two coefficients is 0.08.
Figure 4. Unemployment and CPI inflation, 1976Q1-2011Q4, and the long-run Phillips curve, 1998Q1-2011Q4

Figure 5. The long-run Phillips curve, 1997Q1-2011Q4

Figure 6 shows that starting the sample later and excluding more observations in the beginning do not make the long-run Phillips curve much steeper. The sample 1999Q1-2011Q4 gives a slope equal to –0.78 and an unemployment cost of 0.77 pp.

Figure 7 shows that ending the sample earlier and excluding some observations at the end do not make the long-run Phillips curve much steeper. The sample 1998Q1-2010Q4 gives a slope equal to –0.82 and an unemployment cost of 0.74 pp.
One may want to consider a Phillips curve for CPIXF inflation rather than CPI inflation, where CPIXF inflation refers to CPIX inflation through March 2008 and CPIF inflation from April 2008. One may also, instead of unemployment, want to use the Riksbank’s unemployment gap, that is, the gap between
unemployment and the Riksbank’s estimate of “long-term” unemployment.\(^9\) Figure 8 shows CPIXF inflation and the Riksbank’s estimate of long-term unemployment together with CPI inflation and unemployment.

**Figure 8. CPI and CPIXF inflation, unemployment, and the Riksbank’s estimate of long-term unemployment**

Percent

![Graph showing CPI and CPIXF inflation, unemployment, and the Riksbank’s estimate of long-term unemployment.](image)

Sources: The Riksbank, Statistics Sweden, and TNS Sifo Prospera.

Average real-time CPIXF inflation was 1.64 percent during 1997-2011 and hence fell short of the target by about 0.4 pp. Estimating a long-run Phillips curve for unemployment with CPIXF inflation instead of CPI inflation leads to a flatter long-run Phillips curve with a slope of –0.51 and the same unemployment cost, 0.79 pp. This is shown in figure 9. For CPIXF inflation, the fit is not as good as for CPI inflation. R\(^2\) and adjusted R\(^2\) are 0.65 and 0.63 for CPIXF inflation compared with 0.84 and 0.83 for CPI inflation.

Using CPI inflation with the gap between unemployment and the Riksbank’s estimate of long-term unemployment instead of just unemployment leads to a flatter long-run Phillips curve with a slope of –0.62 and a larger unemployment (gap) cost, 0.97 pp, see figure 10. The fit is marginally worse than with unemployment, with R\(^2\) and adjusted R\(^2\) equal to 0.82 and 0.81, respectively. Interestingly, the average unemployment gap associated with average inflation equal to target is –0.74, indicating that the Riksbank’s estimate is biased upwards. Of course, estimates of some longer-run unemployment rate from observed data from this sample period under the maintained assumption of rational expectations (or even just unbiased expectations) will be biased upwards. Figure 11 shows a revised Riksbank estimate, constructed by just subtracting 0.74 from the Riksbank’s estimate of the long-term unemployment rate. For 2011Q4, the revised and original estimates are 5.8 and 6.5 percent, respectively.

\(^9\) The Riksbank’s estimate of long-term unemployment is shown in Sveriges Riksbank (2010, figure B23).
Figure 9. The long-run Phillips curve with CPIXF inflation and unemployment, 1998Q1-2011Q4

Figure 10. The long-run Phillips curve with CPI inflation and the Riksbank’s unemployment gap, 1998Q1-2011Q4
In the estimated short-run Phillips curve (5), unemployment is considered predetermined and therefore uncorrelated with the error term. If we instead use lagged unemployment on the right side of (5), we get a flatter long-run Phillips curve with a slope of \(-0.64\) and a higher unemployment cost of \(0.94\) pp; see figure 12. The fit is marginally worse with lagged unemployment than with current unemployment, with \(R^2\) and adjusted \(R^2\) 0.83 and 0.82, respectively.

Figure 12. The long-run Phillips curve with CPI inflation and lagged unemployment, 1998Q1-2011Q4
Conclusions
During 1997-2011, average CPI inflation has fallen short of the inflation target of 2 percent by 0.6 percentage points. But average inflation expectations according to the TNS Sifo Prospera survey have been close to the target. Thus, average inflation expectations have been anchored to the target and the target has become credible. If average inflation expectations are anchored to the target when average inflation differ from the target, the long-run Phillips curve is not vertical. Then lower average inflation means higher average unemployment. The data indicate that average inflation below target has been associated with average unemployment being 0.8 percentage points higher over the last 15 years than would have been the case if average inflation had been equal to the target. This is a large unemployment cost of average inflation below a credible target. Some simple robustness tests indicate that the estimate of the unemployment cost is rather robust, but the estimate is preliminary and further scrutiny is needed to assess its robustness.

The difference between average inflation and average inflation expectations and the apparent existence of a downward-sloping long-run Phillips curve raises several urgent questions that I believe need to be addressed. Why have average inflation expectations exceeded average inflation for 15 years? Why has average inflation fallen below the target for 15 years? Could average inflation have fallen below average inflation expectations and the inflation target without the large unemployment cost estimated here? Could the large unemployment cost have been avoided with a different monetary policy? What are the policy implications for the future? Do these findings make price-level targeting or the targeting of average inflation over a longer period relatively more attractive, since they would better ensure that average inflation over longer periods equals the target?

References


